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Various conditioning methods for root canals influencing the tensile strength of titanium posts

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SUMMARY Conditioning the root canal is frequently advised to achieve high post-retention when resin composite luting cements are used. However, manufacturers' instructions for this purpose differ widely from one another. The aim of this study was to compare the tensile bond strengths of passive, tapered, titanium root posts that were luted with four different resin composite cements (Compolute® Aplicap, Flexi-Flow cem™, Panavia® 21 EX, Twinlook®) in the root canals at three conditions, namely (i) no conditioning, (ii) etching with 37% phosphoric acid, and (iii) etching + bonding agent application. Panavia 21 EX was further tested after using the primer for the post-surface according to the manufacturer's recommendations. The posts luted with zinc phosphate cement (Tenet) acted as the control group. Following endodontic preparation of 140 intact anterior teeth with hand instruments, the post-spaces were prepared using the opening drills of the corresponding size of the posts. The samples were first stored in water at 37 °C for 24 h and then thermocycled (5000 cycles, 5–55 °C, 30 s). The tensile strength values were measured with the universal testing machine at a crosshead speed of 0·5 mm min^{-1}. The data were analysed statistically using ANOVA and corrected with Scheffé test due to the significance levels ($P < 0·05$). The tensile bond strengths of the titanium posts after luting with various cements and thermocycling were affected by the conditioning systems used for the root canals. Tensile bond strengths were the highest with Flexi-Flow (475 ± 78 N) followed in descending order by Panavia 21 EX (442 ± 97 N), Twinlook (430 ± 78 N) and Compolute Aplicap (352 ± 76 N) after conditioning the root canal. The use of primer on the post improved the tensile bond strength compared with the non-conditioned group for the Panavia 21 EX group (375 ± 77 N) ($P < 0·001$). Tensile bond strengths obtained after luting the posts with zinc phosphate cement (414 ± 102 N) were not significantly different ($P < 0·05$) than those of resin composite cements. Although the importance of conditioning the root canal was evident for Panavia 21 EX, it was not the case for the other luting cements tested.

KEYWORDS: post, luting cements, conditioning techniques

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Introduction

The retention ability of passive tapered posts is reported to be less when compared with active posts or passive parallel posts. Therefore, it is necessary to improve the retention when this kind of post is chosen (1, 2). The use of resin composite luting cements has been widely stated to reveal superior post-retention, less solubility and microleakage in comparison with zinc phosphate cements (2–14).

The higher retention strengths are due to the bonding capacity of resin composite to dentine walls in the root canal through chemical adhesion. Some previous studies implied that resin composite cements offer additional strength and retention through chemical adhesion to the dentine walls (11–14). The use of composite cements was also recommended because of their ability to deform under stress (12). However, resin composite cements differ in chemistry and therefore they are reported to exhibit different performances with regard to their retentive strength (4–7, 15).

The conditioning and bonding mechanisms of composites to the root canal wall have not been widely studied (8, 12). Different conditioning methods have been recommended by the manufacturers for various composite cements. The sensitivity of composite cements to variables during the cementation was reported to have disadvantages (10, 15, 16). Conditioning the root canal is frequently advised to achieve high post-retention when resin composite luting cements are used. However, manufacturers' instructions for this purpose differ widely with some manufacturers not recommending conditioning of the dentine walls. It is therefore important to find a reliable luting method which has the ideal connection between the root canal, cement and the post that can improve the survival rate of the posts.

The aim of this study was to compare the tensile bond strengths of passive, tapered, titanium root posts that were luted with four different resin composite cements (Compolute®,* Flexi-Flow cem™,† Panavia® 21 EX‡ and Twinlook®§) after conditioning the root canals with three methods.

Materials and methods

Passive tapered titanium posts¶ with sandblasted surfaces ($R_Z = 12{\cdot}4$ μm) size II and length (12 mm) were used for this study. A total of 140 newly extracted non-carious human anterior teeth were stored in physiological saline solution before use. The clinical crowns were removed perpendicular to the long axis of the root using a band saw.** The root canals were endodontically prepared using hand instruments up to one size smaller than the respective post space preparation instrument. The post spaces were prepared using the corresponding opening drills for each post system. The post spaces were copiously irrigated with 1·5% sodium hypochlorite and dried with paper points.††

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¶Erlangen Post System, Brasseler USA, Savannah, GA, USA.
**Exact band system®, Norderstedt, Germany.
††Roeko, Langenau, Germany.

Fourteen experimental groups, each containing 10 roots, were formed for five cement types and surface conditioning systems. The effect of three conditions, namely (i) no conditioning, (ii) etching with 37% phosphoric acid, and (iii) etching + bonding agent application, on the tensile bond strength of tapered passive titanium posts were evaluated after cementing the posts with four types of resin composite luting cements (Compolute, Flexi-Flow cem, Panavia 21 EX and Twinlook). Panavia 21 EX was further tested after using the primer for the post surface according to the manufacturer's recommendations. The posts luted with zinc phosphate cement (Tenet‡‡) were considered as the control group. The luting cements were mixed and applied following the manufacturers' instructions.

All specimens were first stored in water for 24 h at 37 °C and then subjected to thermocycling for 5000 cycles between 5 and 55 °C. They were then mounted in the jig of the universal testing machine§§ and tensile force at a crosshead speed of 0·5 mm min^{-1} was applied to the posts until they debonded from the root canals.

The data were analysed statistically using ANOVA test and corrected with Scheffé test due to the significance levels ($P < 0{\cdot}05$) (SPSS-Version 7.0. StatView 5.0¶¶).

Results

Figure 1(a–d) shows the mean tensile strength values obtained, together with the standard deviations and significant differences associated with the luting cements after each conditioning system used for the root canal walls.

The tensile bond strengths of the titanium posts luted with various cements were affected by the conditioning systems used for the root canals. Tensile strengths were highest with Flexi-Flow (475 ± 78 N) followed in descending order, by Panavia 21 EX (442 ± 97 N), Twinlook (430 ± 78 N) and Compolute Aplicap (352 ± 76 N) after conditioning the root canal.

The use of primer on the post surface improved the tensile bond strength for the Panavia 21 EX (375 ± 77 N) compared with the non-conditioned group ($P < 0{\cdot}001$). Tensile strengths obtained after luting the posts with zinc phosphate cement (414 ± 102 N)

‡‡Vivadent Inc., Amherst, NY, USA.
§§Lloyd LRX, Lloyd Instruments Ltd, Fareham, UK.
¶¶SAS Institute Inc., Cary, NC, USA.

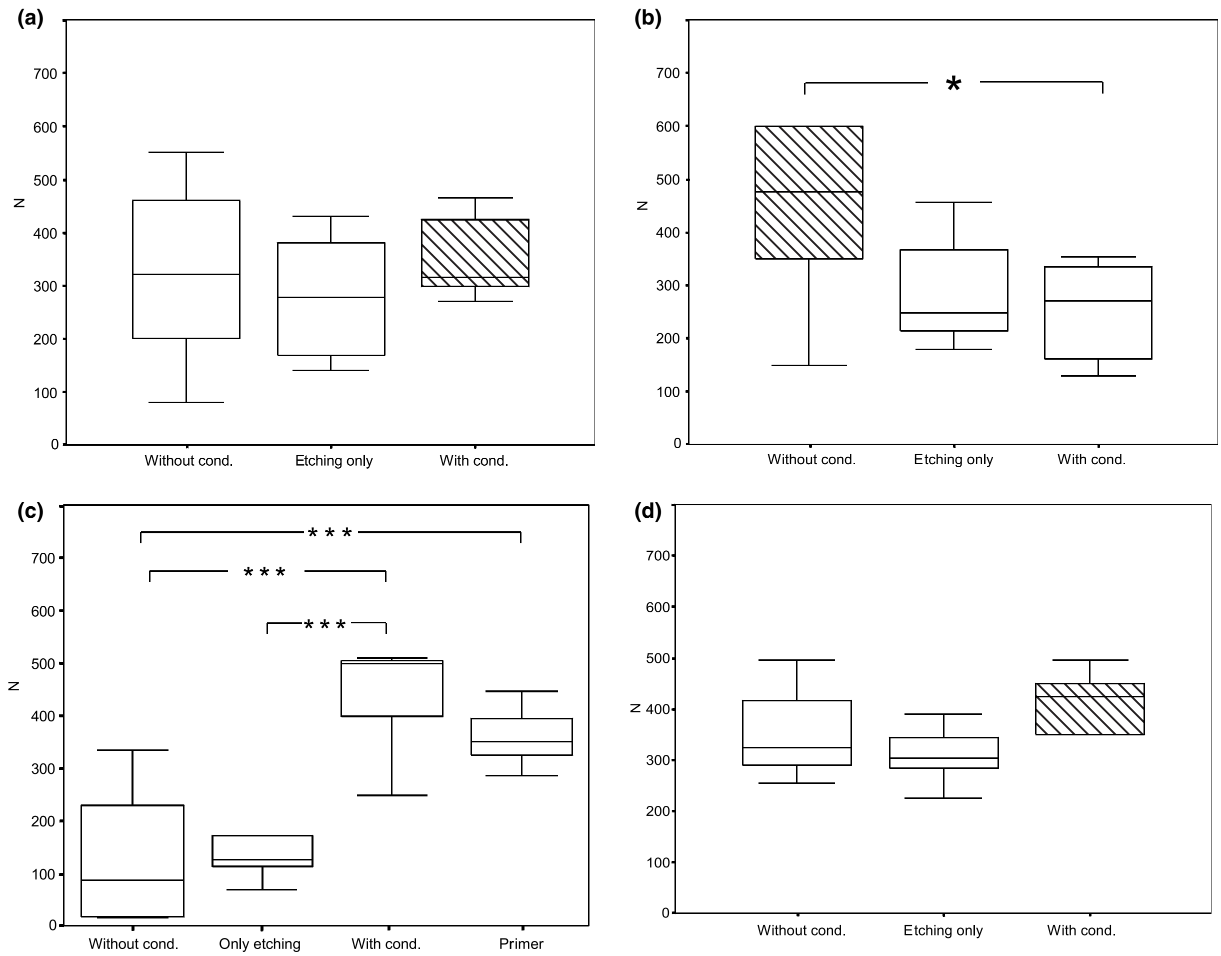

Fig. 1. (a) Tensile bond strength of the posts cemented with Compolute® Aplicap at three conditions. No significant differences were found between the groups (*$P > 0{\cdot}05$). (b) Tensile bond strength of the posts cemented with Flexi-Flow cem™ at three conditions. Note the significant difference between unconditioned and conditioned group (*$P < 0{\cdot}05$). (c) Tensile bond strength of the posts cemented with Panavia® 21 EX. Note the significantly less bond strength in non-conditioned group compared with conditioned group (***$P < 0{\cdot}001$). The use of primer on the post improved the tensile strength compared with the non-conditioned group (***$P < 0{\cdot}001$). (d) Tensile strength of the posts cemented with Twinlook® cement at three conditions. No significant differences were found between the groups (*$P > 0{\cdot}05$).

were not significantly different ($P < 0{\cdot}05$) from those of resin composite cements. Conditioning the root canal improved the tensile bond strength for Panavia 21 EX but this was not the case for the other luting cements tested.

The various composite luting cements did not show significant differences ($P > 0{\cdot}05$) with each other and also not with zinc phosphate ($P > 0{\cdot}05$) when applied in accordance with the manufacturers' recommendations (Fig. 2).

Discussion

Chemical adhesion of the luting cement is preferred for the retention of posts in order to avoid microleakage and fractures when composite cements are used as luting agents. Resin-based cements should be used in conjunction with dentine-bonding agents to provide adequate retention. Various cements offer adhesion-promoting agents based on etching, priming or bonding. Etching removes the smear layer plugs from the dentinal tubules demineralizes the superficial dentine and therefore allows for better penetration of bonding agents. The bonding agent was expected to diffuse into the dentinal tubules and into the collagenous fibre network of the demineralized dentine thus forming a hybrid layer (17). Controversial findings are reported in the literature showing composite cements to be superior to those of conventional cements (3–7, 9, 10, 12,

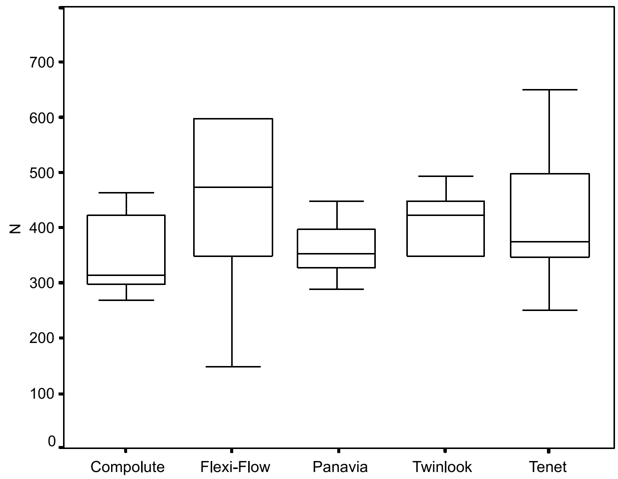

Fig. 2. Tensile bond strength of the posts luted with five cements only according to the manufacturers' recommendations. No significant differences were found between the control group luted with zinc phosphate cement (Tenet) and the resin composite cements (Compolute® Aplicap, Flexi-Flow cem™, Panavia® 21 EX and Twinlook®) (*$P > 0{\cdot}05$).

14). Some authors agreed on the positive effect of composite resins on retention but questioned if this effect could also be achieved *in vivo* due to the technique sensitivity of these cements (10, 15, 16). The present study confirmed this technique sensitivity when composites were used for cementation of posts. The exceptions were Compolute Aplicap and Twinlook where tensile strength was not influenced by the various conditioning methods used for the root canal wall.

The variation in retention of the resin cements could be explained by changes in the width of the dentinal tubules, the collapsed collagen network or the reduced moisture content of endodontically treated teeth (17–20). Dietschi *et al.* (8) reported low adhesion of Panavia 21 EX to the apical root dentine because of the lack of resin tags within the dentinal tubules. On the contrary, this cement, which is a phosphate monomer (MDP) containing resin composite luting cement, is reported to offer good bonding ability to all substrates and especially to titanium (12, 21). The present findings supported the theory that Panavia 21 EX needs the formation of a hybrid layer to form a chemical adhesion as the tensile strength was significantly reduced when no conditioning or only etching was used. The primer used for this cement had a self-etching and self-conditioning effect that was comparable with separate etching and bonding. This explains why similar results were found for both conditioning methods. Moreover, Flexi-Flow which is a bis-GMA composite cement also demonstrated higher results than that of the MDP-based cement.

When a passive fitting post is used, the retention relies heavily on close adaptation of the post to the root canal wall and the cement layer. In accordance with some authors (13, 18, 22), this study found no significant difference between the retention of conventional zinc phosphate cement and the composite cements tested. The post system used in this study, was developed to be used with zinc phosphate cement. Although an additional chemical adhesion was expected, the results proved that the retention of these posts could not be further enhanced when composite cement is used. The form congruency of the post tested produces an ideal cement gap with some surface roughness that is supplied by the manufacturer. A homogeneous cement with a thin film thickness is of great importance with a passive fit post, providing considerable retentive strength. Probably for this reason, sufficient tensile bond strength values were obtained with the zinc phosphate cement as the rough surface offered mechanical retention for the cement to set into these interlockings.

In the present study, the root canals of extracted teeth were prepared for the post space without previously performing a root canal filling. It should also be anticipated that incomplete removal of the root canal filling along the post space would have an adverse effect on bond strength of the luting cement to the canal walls. Therefore, zinc phosphate can still serve as a good choice of luting cement with a roughened surface. Moreover, zinc phosphate cements are cheaper luting agents compared with their resin composite counterparts, and will allow removal of the post from the canals more easily than some of the resin cements should when need arise.

Conclusions

Although the importance of conditioning the root canal was evident for Panavia 21 EX, etching and bonding agent applications did not improve the tensile bond strengths of the posts when Compolute, Twinlook and Flexi-Flow cem resin composite cements were used. When the manufacturers' recommendations were followed, no significant difference was found between the resin-composite luting cements. Zinc phosphate cement exhibited tensile bond strengths comparable with resin composite cements.

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